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(54) **Combination sailboat-powerboat hull**

(57) A combination sailboat-powerboat hull is constituted by a round-bottom ballasted displacement hull (1) provided with generally horizontal foils (11) that extend along the static water line (7) on both sides of the hull (1) from approximately amidships (8) to the transom (3). The foils (11) extend into but do not penetrate through the boundary layer at sailing speed and therefore have minimal effect on the sailing characteristic of the hull (1). Under auxiliary power, the undersurfaces of the foils (11) provide hydrodynamic lifting force to support the aft sections thereby permitting higher speeds which would otherwise swamp the stern.

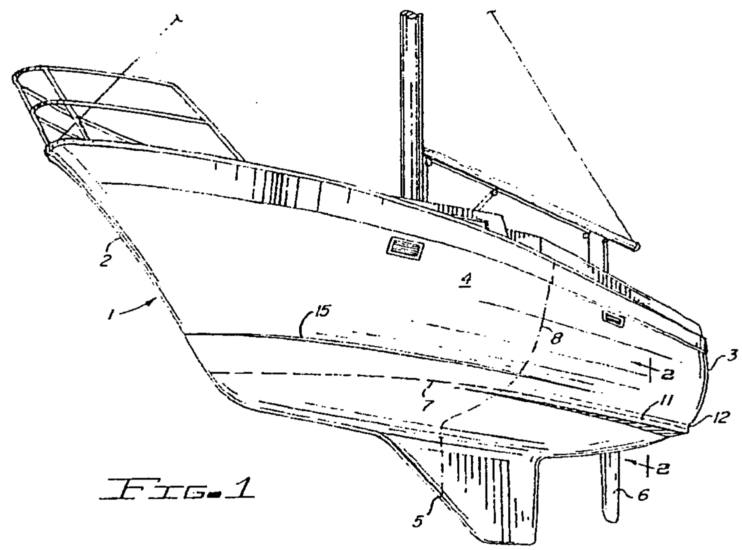

FIG-1

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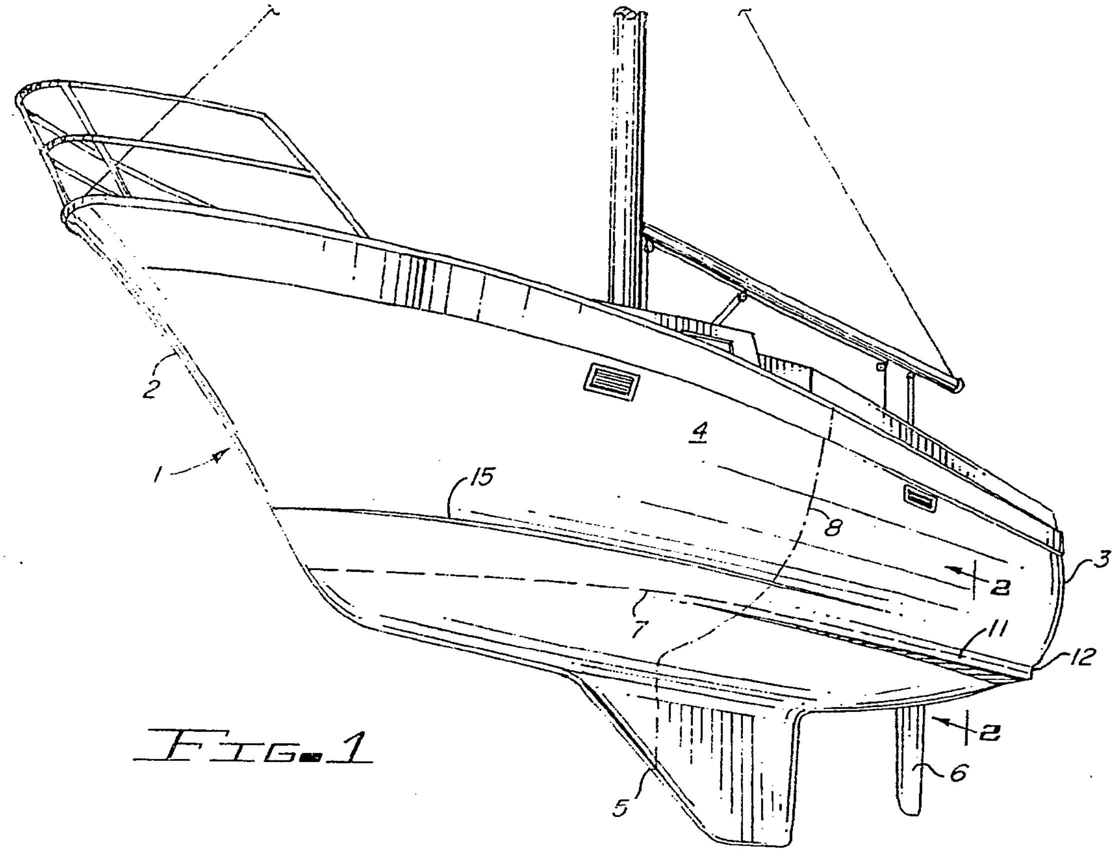

FIG. 1

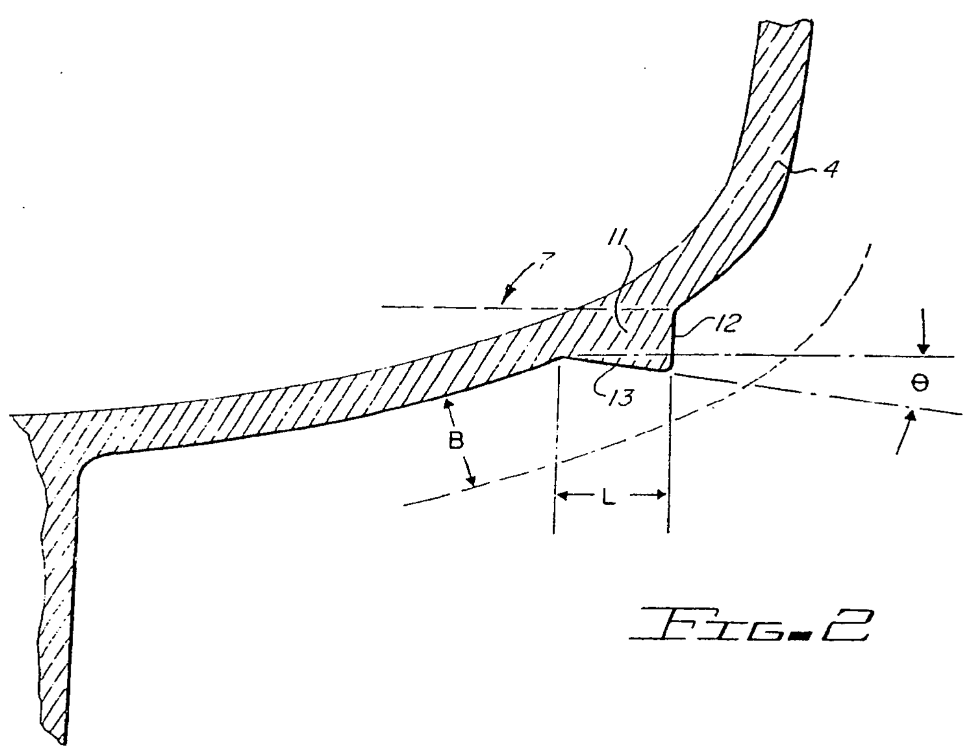

FIG. 2

SPECIFICATION

Combination sailboat - powerboat hull

This invention relates to boat hulls and, more particularly to a combination sailboat-powerboat hull.

The art and science of hull design for powerboats and sailboats are highly developed. To date, however, it has not been possible to construct a single hull which gives optimum performance under both sail and power. Sailing hulls and power hulls, according to traditional design criteria, have widely differing underwater shapes. The traditional monohull sailboat has a tapered cross section resembling the bottom of a wine goblet, carrying at its bottom a ballasted vertical keel which generally extends a substantial distance below the hull to provide righting force and to present additional lateral surface to resist forces tending to push the boat sideways. These righting forces and lateral resistance forces offset the tendency of the boat to heel too severely and to make undesirably high leeway under sail. The design of high performance sailing hulls has reached the point that most modern production and custom boats can routinely achieve speeds which are equal or very nearly equal to the theoretical "hull speed" which is imposed by surface tension effects and energy losses sustained when such hulls create bow waves.

According to conventional sailing hull design criteria, the so-called "round-bottom", ballasted displacement hull should have prismatic coefficient of from about 0.50 to about 0.54 in order to achieve the necessary combination of "stiffness" (resistance to over-heeling), streamlining (to reduce underwater drag) and directional stability. Such sailing hulls have a maximum theoretical speed or "hull speed", expressed in knots, of approximately 1.4 multiplied by the square root of the waterline length in feet (where the waterline length is expressed in metres, the "hull speed" is approximately 2.53 times the square root of the waterline length). For example, a properly shaped sailboat hull which has a waterline length of 36 feet (10.98m) would have a hull speed of 1.4×6 or 8.4 knots. Expressed alternatively, the so-called "speed to length ratio" (in reality, the speed to square root of length ratio) of such a hull is said to approach 1.4 as a theoretical maximum where waterline length is expressed in feet (or 2.53 for waterline length in metres).

The practical significance of this phenomenon is that, after the boat reaches this maximum speed, the application of additional propulsive force, e.g., by increasing the sail area or the size of an auxiliary engine, will not cause a corresponding increase in the speed of the boat. Instead, as additional motive power is applied it is simply dissipated in the creation of a wake. This wake is created when a so-called "displacement hull" (which supports the weight of a boat by displacing an equal weight of water) pushes the water aside as the hull moves through the water. If sufficient additional power is applied, the boat will simply sink when its stern is swamped and pulled under water in the stern wake.

This phenomenon is avoided if the underwater configuration of the hull is flattened to provide an essentially horizontal surface which causes the hull to "plane", such that the weight of the boat is supported by the upward hydrodynamic forces generated at the interface of the planing surface and the water surface. Under these conditions the hull does not displace enough water to create the energy-dissipating stern wake.

Various attempts have been made to combine the characteristics of "displacement" hulls and "planing" hulls so as to provide a hull which will be suitable for use both under power and under sail. However, such prior attempts have never produced a completely satisfactory result. These so-called "motorsailor" hulls have, in the past, ineluctably resulted in a compromise of both the sailing and the motoring characteristics of the hull. The sailing characteristics (stiffness, directional stability and windward sailing ability) were compromised by the somewhat flatter bottom which was provided in order to achieve a partial planing effect under auxiliary power. The characteristics of the hull under auxiliary power (drag effects) were compromised when the hull was deepened and provided with a partial keel which were provided in order to obtain some measure of these desired sailing characteristics.

This compromise in the design of motorsailer hulls is usually expressed numerically by a ratio such as 50:50, 70:30 or 40:60, which attempted to roughly indicate the relative abilities of a given motorsailer hull under sail and under auxiliary power. Thus, a motorsailer hull in which the compromise was roughly equal was said to be a 50:50 hull. A 70:30 motorsailer hull is one in which the primary emphasis is upon sailing ability. The 40:60 hull is a design which is slightly compromised in favour of the characteristics of the hull under auxiliary power.

It would be highly desirable to provide a hull which has auxiliary power characteristics which are very close or very nearly equal to those exhibited by conventional "deep V" planing powerboat hulls and which also have highly desirable sailing characteristics (stiffness, directional stability and pointing ability) and which can be sailed at very nearly theoretical "hull speed".

It is therefore, an object of the present invention to provide a combination sail and auxiliary power boat hull which will have superior sailing and auxiliary power characteristics in comparison to conventional motorsailer hulls.

According to one aspect of the present invention, there is provided a combination sailboat-powerboat hull in the form of a round-bottom, ballasted displacement hull having a prismatic coefficient of about 0.50 to 0.54, said hull being provided with generally horizontal foils which extend along the static water line on both sides of the hull, the forward ends of the foils being faired into the hullsides approximately amidships from where the foils extend rearwardly towards the quarters, and the foils extending out from the hullsides a distance less than the thickness of the boundary layer at sailing hull speed, the undersurface area of the foils

being such as to enable the hull to plane when driven under auxiliary power.

As used herein the term "round-bottom" hull is intended to indicate that the hulls of the present invention have the traditional, generally "wine-glass" shaped cross section commonly associated with displacement-type-hulls as distinguished from hard-chine, substantially flat bottomed hulls (commonly unballasted) which are sometimes employed in sailboats, particularly shallow draft boats such as sailing dinghies and sailing scows. Such flat-bottom sailing hulls are essentially planing hulls as distinguished from displacement hulls, i.e., they have a speed to length ratio of at least about 2.5 as distinguished from displacement hulls which have a theoretical maximum speed to length ratio of about 1.4 (these figures apply to waterline lengths in feet - for waterline lengths in metres, the corresponding figures are 4.52 and 2.53).

The term "prismatic coefficient", as used herein, is a term of art used by naval architects in describing the underwater shape of boat hulls and is used herein in that technical sense.

As indicated, the foils are faired into the hull-sides approximately amidships, i.e., approximately at the point aft of the stem of maximum hull width. The foils extend rearwardly toward the quarters, preferably to the transom. Preferably, the foils are formed integrally with the hull and have a generally triangular cross section, including a substantially vertical surface extending downwardly from the hullsides and a generally horizontal undersurface extending outwardly from the hullsides. The foil is shaped and dimensioned such that it therefore extends into the boundary layer at sailing hull speed. The term "boundary layer", as will be understood by those skilled in the art, refers to the zone of turbulent flow which extends perpendicularly outwardly from the hull when the hull moves through the water between the hull and water which is in laminar flow. However, the foils are dimensioned such that they do not extend through the boundary layer into the laminar zone. Consequently, while improving the speed/length ratio of the hull under auxiliary power, under sail the foils do not materially contribute to drag, allowing the boat to perform at substantially theoretical hull speed under sail.

The undersurfaces of foils are generally horizontal but may preferably be inclined upwardly and inwardly at an angle of up to 10°, preferably about 7° to provide optimum lifting force at planing speed. The upward directed hydrodynamic lifting force provided by these generally horizontal lifting surfaces prevent quarters of the hull from being dragged downwardly by the stern wake.

Hulls embodying the invention can achieve very nearly theoretical hull speed when under sail, having regard for their waterline length but will also plane under sufficient auxiliary power at a speed substantially in excess of theoretical hull speed (for example, up to five or six times theoretical hull speed).

According to another aspect of the present invention, there is provided a combination sailboar-powerboat hull having a speed/length ratio substantially exceeding 1.4 where the hull length is expressed in feet, the hull including:

(a) means defining a round-bottom, ballasted displacement hull having a prismatic coefficient of about 0.50 to 0.54;

(b) generally horizontal foils extending along the static water line on both sides of the hull, the foils

(i) having their forward ends faired into the hullsides approximately amidships,

(ii) extending rearwardly toward the quarters,

(iii) extending outwardly from the hullsides a distance less than the thickness of the boundary layer at sailing hull speed,

the undersurfaces of said foils being inclined upwardly inwardly at an angle of from about 0°-10° and having a combined area at least equal to

$$\left[\frac{D}{C_L \times P/2 \times V^2}\right] \quad 0.5$$

where

D = the displacement of the hull,

C_L = the coefficient of lift,

P = the mass density of water, and

V = the design takeoff planing velocity.

A sailboat hull embodying the present invention will now be particularly described, by way of example, with reference to the accompanying diagrammatic drawing, in which:

Figure 1 is a perspective view of the boat hull embodying the invention; and

Figure 2 is a cross sectional view of the hull of Figure 1 taken along section line 2-2 thereof.

Figure 1 depicts a generally conventionally configured sailboat hull, generally indicated by reference numeral 1 having a stem 2, transom 3, hullsides 4, ballasted keel 5 and rudder 6. The static waterline is indicated by reference numeral 7. Commencing at approximately amidships, indicated by the vertical counter line 8, and extending rearwardly toward the quarters 9 of the hull 1, generally horizontal foils 11 are formed on both sides of the hull integrally with the hull 1. The forward ends of the foils 11 are broken away as they are faired into the hullsides 4 at approximately amidships 8. The foils are of generally triangular cross section.

Referring to Figure 2, it will be seen that the foils 11 are of generally triangular cross section with the vertical face 12 extending downwardly from the hullsides 4 and the undersurface 13 extending outwardly a length L such that the apex of the vertical face 12 and undersurface 13 is located within the boundary layer B and does not extend through the interface 14 between the boundary layer B and the water laminar flow.

As indicated, the undersurface 13 of the foil may be inclined upwardly and inwardly toward the hullsides 4 at an angle θ of 0°-10°, preferably about 7°.

The combined undersurface area of the foils 11 is made at least equal to

$$\left[\frac{D}{C_L \times P/2 \times V^2}\right] \quad 0.5$$

where

D = the displacement of the vessel,

C_L = the coefficient of lift,

P = the mass density of water, and

V = the design takeoff planing velocity.

C_L, the coefficient of lift, is a dimensionless number characteristic of the amount of lift required to cause the hull to plane at a speed to length ratio of at least 2.5 (for length in feet, or 4.52 for length in metres).

The foils 11 of the present invention are to be carefully distinguished from so-called lifting strakes which are commonly provided on the bow sections of powerboats for the purpose of causing the hull to more readily assume the characteristic inclined position more favourable for planing hulls. In fact, because of their location on hulls constructed in accordance with the present invention, the foils tend to provide just the opposite effect, i.e., tend to raise the stern with respect to the bow, causing the hull to assume a more horizontal attitude under power than a conventional powerboat hull.

According to the presently preferred embodiment of the invention, optional spray deflector portions 15 are formed integrally in the hull, these portions 15 being faired into the hull at the stem 2 and terminating, as shown in Figure 1, slightly aft of amidships 8. These spray deflector portions 15 have essentially no hydrodynamic effect and are provided simply for the indicated purpose of keeping the deck dry by deflecting the spray produced at the bow outwardly.

As applied to a hull having an overall length of 26'7" (8.1m) which has a waterline length of 22'0" (6.72m), a beam of 8'7" (2.62m), a draft of 4'3" (1.30m) a displacement of 4,600 pounds (2088 kg), ballast of 1,700 pounds (772 kg), a displacement/length ratio of 197 and a sail area to displacement ratio of 17.29, the principles of the present invention are employed to provide a boat having a sailing hull speed of 6.57 knots. This same boat powered by 140 horsepower outboard engine will cruise at 15 knots, i.e., a speed/length (ft) ratio of 3.20 (or 5.78 for length in metres). If the power of the engine is increased to 235 horsepower the boat will cruise at 22 knots or a speed/length (ft) ratio of 5 (or 9 for length in metres).

CLAIMS

1. A combination sailboat-powerboat hull in the form of a round-bottom, ballasted displacement hull having a prismatic coefficient of about 0.50 to 0.54, said hull being provided with generally horizontal foils which extend along the static water line on both sides of the hull, the forward ends of the foils being faired into the hullsides approximately amidships from where the foils extend rearwardly towards the quarters, and the foils extending out from the hullsides a distance less than the thickness of the boundary layer at sailing hull speed, the undersurface area of the foils being such as to enable the hull to plane when driven under auxiliary power.

2. A combination sailboat-powerboat hull according to Claim 1, wherein the foils are formed integrally with the hull and have a generally triangular cross-section including a substantially vertical surface extending downwardly from the hullsides and a generally horizontal undersurface extending outwardly from the hullsides.

3. A combination sailboat-powerboat hull according to Claim 1 or Claim 2, wherein the undersurfaces of said foils are upwardly and inwardly inclined at an angle of up to 10°.

4. A combination sailboat-powerboat hull having a speed/length ratio substantially exceeding 1.4 where the hull length is expressed in feet, the hull including:

(a) means defining a round-bottom, ballasted displacement hull having a prismatic coefficient of about 0.50 to 0.54;

(b) generally horizontal foils extending along the static water line on both sides of the hull, the foils

(i) having their forward ends faired into the hullsides approximately amidships,

(ii) extending rearwardly toward the quarters,

(iii) extending outwardly from the hullsides a distance less than the thickness of the boundary layer at sailing hull speed,

the undersurfaces of said foils inclined upwardly inwardly at an angle of from about 0°-10° and having a combined area at least equal to

$$\left[\frac{D}{C_L \times P/2 \times V^2}\right] \quad 0.5$$

where

D = the displacement of the hull,

C_L = the coefficient of lift,

P = the mass density of water, and

V = the design takeoff planing velocity.

5. A combined sailboat-powerboat hull substantially as hereinbefore described with reference to the accompanying drawing.

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